EXHIBIT 10

NFPA®

921

Guide for
Fire and Explosion
Investigations

Guide | 2024

NFPA®

NFPA 921

Guide for

Fire and Explosion Investigations

2024 Edition

IMPORTANT NOTE: This NFPA document is made available for use subject to important notices and legal disclaimers. These notices and disclaimers appear in all publications containing this document and may be found under the heading "Important Notices and Disclaimers Concerning NFPA Standards." They can also be viewed at www.nfpa.org/disclaimers or obtained on request from NFPA.

UPDATES, ALERTS, AND FUTURE EDITIONS: New editions of NFPA codes, standards, recommended practices, and guides (i.e., NFPA Standards) are released on scheduled revision cycles. This edition may be superseded by a later one, or it may be amended outside of its scheduled revision cycle through the issuance of Tentative Interim Amendments (TIAs). An official NFPA Standard at any point in time consists of the current edition of the document, together with all TIAs and Errata in effect. To verify that this document is the current edition or to determine if it has been amended by TIAs or Errata, please consult the National Fire Codes® Subscription Service or the "List of NFPA Codes & Standards" at www.nfpa.org/docinfo. In addition to TIAs and Errata, the document information pages also include the option to sign up for alerts for individual documents and to be involved in the development of the next edition.

NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced and extracted publications can be found in Chapter 2 and Annex C.

Chapter 1 Administration

1.1 Scope. This document is designed to assist individuals who are charged with the responsibility of investigating and analyzing fire and explosion incidents and rendering opinions as to the origin, cause, fire spread, responsibility, or prevention of such incidents and the damage and injuries that arise from such incidents.

1.1.1 The completion of reports for the United States National Fire Incident Reporting System (NFIRS) are outside the scope of this guide.

1.1.2 This guide considers NFIRS reports as incident reports and not as investigation reports. The information contained in an NFIRS report should generally be considered as the preliminary report of the fire department concerning any fire or explosion incident. An NFIRS report should not be used as a fire investigation report.

Δ **1.2 Purpose.**

1.2.1 The purpose of this document is to establish guidelines and recommendations for the safe and systematic investigation or analysis of fire and explosion incidents. Fire investigation or analysis and the accurate listing of causes are fundamental to the protection of lives and property from the threat of hostile fire or explosions. It is through an efficient and accurate determination of the cause and responsibility that future fire incidents can be avoided. This document has been developed as a model for the advancement and practice of fire and explosion investigation, fire science, technology, and methodology.

1.2.2 Proper determination of fire origin and cause, as well as the cause of and responsibility for property damage, injuries, or deaths, is also essential for the meaningful compilation of fire statistics. Accurate statistics form part of the basis of fire prevention codes, standards, and training.

1.3 Application. This document is designed to produce a systematic, working framework or outline by which effective fire and explosion investigation and origin and cause analysis can be accomplished. It contains specific procedures to assist in the investigation of fires and explosions. These procedures represent the judgment developed from the NFPA consensus process system that if followed can improve the probability of reaching sound conclusions. Deviations from these procedures, however, are not necessarily wrong or inferior but need to be justified.

1.3.1 The reader should note that frequently the phrase *fire investigation* is used in this document when the context indicates that the relevant text refers to the investigation of both fires and explosions.

1.3.2 As every fire and explosion incident is in some way unique and different from any other, this document is not designed to encompass all the necessary components of a complete investigation or analysis of any one case. The scientific method, however, should be applied in every instance.

1.3.3 Not every portion of this document may be applicable to every fire or explosion incident. It is up to investigators (depending on their responsibility, as well as the purpose and scope of their investigation) to apply the appropriate recommended procedures in this guide to a particular incident.

1.3.4 In addition, it is recognized that the extent of the fire investigator's assignment, time and resource limitations, or existing policies may limit the degree to which the recommendations or techniques in this document will be applied in a given investigation.

1.3.5 This document is not intended as a comprehensive scientific or engineering text. Although many scientific and engineering concepts are presented within the text, the user is cautioned that additional scientific or technical resources, training, and education may often need to be utilized in an investigation.

1.4 Units of Measure. Metric units of measurement in this guide are in accordance with the modernized metric system known as the International System of Units (SI). The unit of liter is outside of but recognized by SI and is commonly used in international fire protection. These units are listed in Table 1.4.

Chapter 4 Basic Methodology

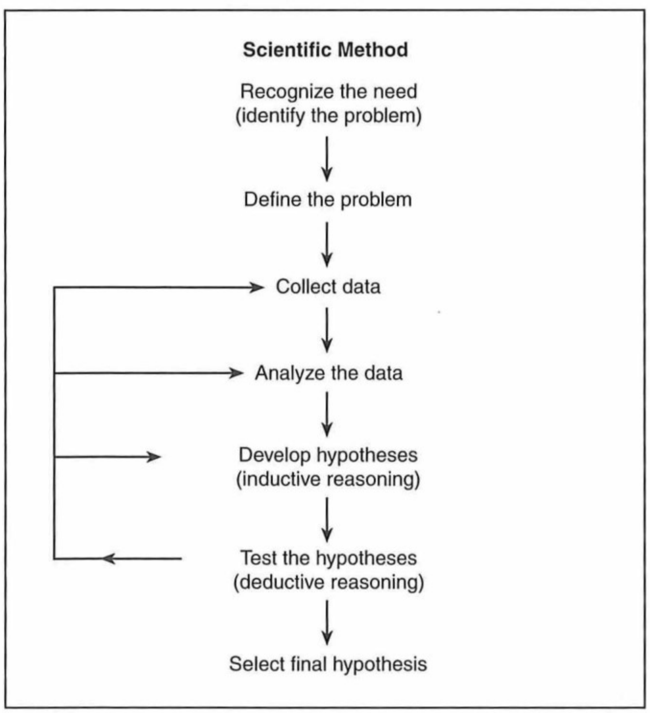
4.1* Nature of Fire Investigations. As a forensic science discipline, fire or explosion investigation is a complex endeavor involving skill, technology, knowledge, and science. The compilation of factual data, as well as an analysis of those facts, and expressing opinions or conclusions in reports or testimony, should be accomplished objectively, truthfully, and without expectation bias, preconception, or prejudice. The basic methodology of the fire investigation should rely on the use of a systematic approach and attention to all relevant details. The use of a systematic approach often will uncover new factual data for analysis, which may require previous conclusions to be reevaluated. With few exceptions, the proper methodology for a fire or explosion investigation is to first determine and establish the origin(s), then investigate the cause: circumstances, conditions, or agencies that brought the ignition source, fuel, and oxidant together.

4.2 Systematic Approach. The systematic approach recommended is based on the scientific method, which is used in the physical sciences. This method provides an organizational and analytical process that is desirable and necessary in a successful fire investigation.

4.3 Relating Fire Investigation to the Scientific Method. The scientific method *(see Figure 4.3)* is a principle of inquiry that forms a basis for legitimate scientific and engineering processes, including fire incident investigation. It is applied using the following steps outlined in 4.3.1 through 4.3.10.

4.3.1 Recognize the Need(s). First, one should determine the problem statement(s) or the question(s) that needs to be addressed.

4.3.2 Define the Problem. Having determined that a problem exists, the investigator or analyst should define the manner in which the problem can be solved. In this case, a proper origin and cause investigation should be conducted. This is done by an examination of the scene and by a combination of other data collection methods, such as the review of previously conducted investigations of the incident, the interviewing of witnesses or other knowledgeable persons, and the results of scientific testing.



Δ FIGURE 4.3 Use of the Scientific Method.

4.3.3 Collect Data. Information about the fire or explosion incident is now collected by observation, experiment, or other direct data-gathering means. The data collected is called empirical data because it is based on observation or experience and is capable of being verified or known to be true. Data collection can occur at nearly every stage of the fire investigation.

4.3.4* Analyze the Data. The scientific method requires that all data collected be analyzed. This is an essential step that must take place before the formation of the final hypothesis. The identification, gathering, and cataloging of data does not equate to data analysis. Analysis of the data is based on the knowledge, training, experience, and expertise of the individual doing the analysis. If the investigator lacks expertise to properly attribute meaning to a piece of data, then assistance should be sought. Understanding the meaning of the data will enable the investigator to form hypotheses based on the evidence, rather than on speculation.

4.3.5* Develop Hypotheses (Inductive Reasoning). Based on the data analysis, the investigator produces hypotheses to explain the phenomena, whether it be the nature of fire patterns, fire spread, identification of the origin, the ignition sequence, the fire cause, or the causes of damage or responsibility for the fire or explosion incident. This process is referred to as inductive reasoning. These hypotheses should be based solely on the empirical data that the investigator has collected through observation and then developed into explanations for the event, which are based upon the investigator's knowledge, training, experience, expertise, and research.

4.3.6* Test the Hypotheses (Deductive Reasoning). The investigator does not have a valid or reliable conclusion unless the hypothesis can stand the test of careful and serious challenge. Testing of the hypothesis is done by the principle of deductive reasoning, in which the investigator compares the hypothesis to all known facts as well as the body of scientific knowledge associated with the phenomena relevant to the specific incident. Testing of a hypothesis should be designed to disprove, or refute, the hypothesis. This may also be referred to as falsification of the hypothesis. Working to disprove a hypothesis is an attempt to find all the data or reasons why the hypothesis is not supported or not true, rather than simply finding and relying on data that support the hypothesis or why the hypothesis is true. This method of testing the hypothesis can prevent "confirmation bias," which can occur when the hypothesis or conclusion relies only on supporting data *(see 4.3.10)*. A hypothesis can be tested physically by conducting experiments, analytically by applying accepted scientific principles, or by referring to scientific research. When relying on the research of others, the investigator or analyst must ensure that the conditions, circumstances, and variables of the research and those of the hypothesis are sufficiently similar. Whenever the investigator relies on research as a means of hypothesis testing, references to the research relied upon should be acknowledged and cited. If the hypothesis is refuted or not supported, it should be discarded and alternate hypotheses should be developed and tested. This may require the collection of new data or the reanalysis of

existing data. The testing process needs to be continued until all feasible hypotheses have been tested and one is determined to be uniquely consistent with the facts and with the principles of science. If no hypothesis can withstand an examination by deductive reasoning, the issue should be considered undetermined.

4.3.6.1* Any hypothesis that is incapable of being tested either physically or analytically, is an invalid hypothesis. A hypothesis developed based on the absence of data is an example of a hypothesis that is incapable of being tested. The inability to refute a hypothesis does not mean that the hypothesis is true.

4.3.7 Select Final Hypothesis. The final step in applying the scientific method is to select the final hypothesis. Once the hypothesis has been tested, the investigator should review the entire process to ensure that all credible data are accounted for and all feasible alternate hypotheses have been considered and eliminated. When using the scientific method, the failure to consider alternate hypotheses is a serious error. A critical question to be answered is, "Are there any other hypotheses that are consistent with the data?" The investigator should document the facts that support the final hypothesis to the exclusion of all other reasonable hypotheses.

4.3.8 Avoid Presumption. No specific hypothesis can be reasonably formed or tested until some data have been collected. All investigations of fire and explosion incidents should be approached by the investigator without presumption as to origin, ignition sequence, cause, fire spread, or responsibility for the incident. All hypotheses should be subject to rigorous testing through the scientific method.

Δ **4.3.9 Expectation Bias.** Expectation bias is a phenomenon that occurs when investigator(s) reach a particular conclusion based on expectations without having examined or considered all of the relevant data. Instead of collecting and examining all of the data in a logical and unbiased manner, the investigator(s) uses the premature determination to influence analysis and investigative processes, including suggestive questioning of witnesses, which in turn might influence conclusions in a way that is not scientifically valid. The introduction of expectation bias into the investigation results in the use of only that data that supports this previously formed conclusion and often results in the misinterpretation or the discarding of data that does not support the original opinion. Investigators are strongly cautioned to avoid expectation bias through proper use of the scientific method.

Δ **4.3.10* Confirmation Bias.** Confirmation bias occurs when the investigator relies on data that supports the hypothesis and fails to look for, ignores, or dismisses contradictory or nonsupporting data. The same data may support alternate and even opposing hypotheses. The failure to consider alternate or opposing hypotheses, or prematurely discounting seemingly contradictory data without appropriate analysis and testing can result in incorrect conclusions. Testing a hypothesis is a process that considers all the data and alternative hypotheses to ascertain whether the tested hypothesis is inconsistent with data and, if inconsistent, whether an alternative hypothesis might also be true. When using the scientific method, testing of hypotheses should be designed to disprove a hypothesis (i.e., falsification of the hypothesis), rather than relying only on confirming data that support the hypothesis.

4.4 Basic Method of a Fire Investigation. Using the scientific method in most fire or explosion incidents should involve the steps shown in 4.4.1 through 4.4.6.

4.4.1 Receiving the Assignment. The investigator should be notified of the incident, told what his or her role will be, and told what he or she is to accomplish. For example, the investigator should know if he or she is expected to determine the origin, cause, and responsibility; produce a written or oral report; prepare for criminal or civil litigation; make suggestions for code enforcement, code promulgation, or changes; make suggestions to manufacturers, industry associations, or government agency action; or determine some other results.

4.4.2 Preparing for the Investigation. The investigator should marshal his or her forces and resources and plan the conduct of the investigation. Preplanning at this stage can greatly increase the efficiency and therefore the chances for success of the overall investigation. Estimating what tools, equipment, and personnel (both laborers and experts) will be needed can make the initial scene investigation, as well as subsequent investigative examinations and analyses, go more smoothly and be more productive.

4.4.3 Conducting the Investigation.

4.4.3.1 It is during this stage of the investigation that an examination of the incident fire or explosion scene is conducted. The fundamental purpose of conducting an examination of any incident scene is to collect all of the available data and document the incident scene. The investigator should conduct an examination of the scene if it is available and collect data necessary to the analysis.

4.4.3.2 The actual investigation may include different steps and procedures, which will be determined by the purpose of the assignment. These steps and procedures are described in detail elsewhere in the document. A fire or explosion investigation may include all or some of the following tasks: a scene inspection or review of previous scene documentation done by others; scene documentation through photography and diagramming; evidence recognition, documentation, and preservation; witness interviews; review and analysis of the investigations of others; and identification and collection of data from other appropriate sources.

4.4.3.3 In any incident scene investigation, it is necessary for at least one individual/organization to conduct an examination of the incident scene for the purpose of data collection and documentation. While it is preferable that all subsequent investigators have the opportunity to conduct an independent examination of the incident scene, in practice, not every scene is available at the time of the assignment. The use of previously collected data from a properly documented scene can be used successfully in an analysis of the incident to reach valid conclusions through the appropriate use of the scientific method. Thus, the reliance on previously collected data and scene documentation should not be inherently considered a limitation in the ability to successfully investigate the incident.

4.4.3.4 The goal of all investigators is to arrive at accurate determinations related to the origin, cause, fire spread, and responsibility for the incident. Improper scene documentation can impair the opportunity of other interested parties to obtain the same evidentiary value from the data. This potential impairment underscores the importance of performing comprehensive scene documentation and data collection.

 Shaded text = Revisions. Δ = Text deletions and figure/table revisions. • = Section deletions. *N* = New material.

4.4.4 Collecting and Preserving Data and Evidence. An investigator, depending on their assignment, should properly document, collect, and preserve physical evidence and data relevant to the investigation for further testing and evaluation or courtroom presentation.

4.4.5 Analyzing the Incident. All collected and available data should be analyzed using the principles of the scientific method. Depending on the nature and scope of one's assignment, hypotheses should be developed and tested explaining the origin, ignition sequence, fire spread, fire cause or causes of damage or casualties, or responsibility for the incident.

4.4.6 Conclusions. Conclusions, which are final hypotheses, are drawn as a result of testing the hypotheses. Conclusions should be drawn according to the principles expressed in this guide and reported appropriately.

Δ **4.5 Expert Opinions.** Investigators should understand that there are various legal requirements for the admissibility of expert opinions in different jurisdictions. For example, some courts have set a threshold of certainty for the investigator to be able to render opinions in court. The substantive content of expert reports or testimony should comply with any legal rules imposed by the court or the jurisdiction in which they are provided. *(See Chapter 12 for more information regarding expert witnesses and the admissibility of expert opinions.)* Where experts express their opinions in reports or testimony, they need to articulate how they applied the scientific method and effectively communicate their hypothesis development and testing, disclosing the data collected and utilized. In both reports and testimony, experts should make their opinions transparent, which includes disclosing limitations, if known. If an expert report is required, it should be complete and comprehensive. For further guidance on reporting and testimony, see 16.5.8.

N **4.5.1 Expressions of Certainty.** Someone may express an opinion to a higher or lower level of certainty. The expression is determined by the investigator's confidence in the data, in the analysis of that data, and testing of hypotheses formed.

Δ **4.5.1.1** Two expressions of certainty commonly used are probable and possible, as follows:

(1) *Probable.* This expression corresponds to being more likely true than not.
(2) *Possible.* The hypothesis may be demonstrated to be feasible but cannot be either ruled out or declared probable. If two or more hypotheses are equally likely, then the expression must be "possible."

4.5.1.2 If the level of certainty of an opinion is merely "suspected," the opinion does not qualify as an expert opinion. If the level of certainty is only "possible," the opinion should be specifically expressed as "possible." Only when the level of certainty is considered "probable" should an opinion be expressed with reasonable certainty.

N **4.5.2 Fire Investigation Certainty.** Fire investigators achieve reasonable fire investigation certainty when they have properly applied all of the steps of the scientific method to reach a unique and reliable final hypothesis.

4.6 Review Procedure. A review of a fire investigator's work product (e.g., reports, documentation, notes, diagrams, photos, etc.) by other persons may be helpful, but there are certain limitations. This section describes the types of reviews and their appropriate uses and limitations.

4.6.1 Administrative Review. An administrative review is one typically carried out within an organization to ensure that the investigator's work product meets the organization's quality assurance requirements. An administrative reviewer will determine whether all of the steps outlined in an organization's procedure manual, or required by agency policy, have been followed and whether all of the appropriate documentation is present in the file, and may check for typographical or grammatical errors.

4.6.1.1 Limitations of Administrative Reviews. An administrative reviewer may not necessarily possess all of the knowledge, skills, and abilities of the investigator or of a technical reviewer. As such, the administrative reviewer may not be able to provide a substantive critique of the investigator's work product.

4.6.2 Technical Review. A technical review can have multiple facets. If a technical reviewer has been asked to critique all aspects of the investigator's work product, then the technical reviewer should be qualified and familiar with all aspects of proper fire investigation and should, at a minimum, have access to all of the documentation available to the investigator whose work is being reviewed. If a technical reviewer has been asked to critique only specific aspects of the investigator's work product, then the technical reviewer should be qualified and familiar with those specific aspects and, at a minimum, have access to all documentation relevant to those aspects. A technical review can serve as an additional test of the various aspects of the investigator's work product.

4.6.2.1 Limitations of Technical Reviews. While a technical review may add significant value to an investigation, technical reviewers may be perceived as having an interest in the outcome of the review. Confirmation bias (attempting to confirm a hypothesis rather than attempting to disprove it) is a subset of expectation bias *(see 4.3.9)*. This kind of bias can be introduced in the context of working relationships or friendships. Investigators who are asked to review a colleague's findings should strive to maintain a level of professional detachment.

Δ **4.6.3 Peer Review.** Peer review is a formal procedure generally employed in prepublication review of scientific or technical documents and screening of grant applications by research-sponsoring agencies. Peer review carries with it connotations of both independence and objectivity. Peer reviewers should not have any interest in the outcome of the review. The author does not select the reviewers, and reviews are often conducted anonymously. As such, the term *peer review* should not be applied to reviews of an investigator's work by coworkers, supervisors, or investigators from agencies conducting investigations of the same incident. Such reviews are more appropriately characterized as "technical reviews," as described above.

4.6.3.1 The methodologies used and the fire science relied on by an investigator are subject to peer review. For example, NFPA 921 is a peer-reviewed document describing the methodologies and science associated with proper fire and explosion investigations.

4.6.3.2 Limitations of Peer Reviews. Peer reviewers should have the expertise to detect logic flaws and inappropriate applications of methodology or scientific principles, but because they generally have no basis to question an investigator's data, they are unlikely to be able to detect factual errors or incorrectly reported data. Conclusions based on incorrect data are likely to be incorrect themselves. Because of these limitations, a

proper technical review will provide the best means to adequately assess the validity of the investigation's results.

4.7 Reporting Procedure. The reporting procedure may take many written or oral forms, depending on the specific responsibility of the investigator. Pertinent information should be reported in a proper form and forum to help prevent recurrence.

FIGURE 6.5.10.2 Flash Fire Damage on Plastic Wrapper and Paper Roll.

dynamics of the fire spread will be dictated by the compartment and fuel geometry and the relative heat release rates of these secondary fuels. The relatively short duration of the burning may have little impact on the flashover in the compartment as compared to the burning of the secondary fuels. Therefore, origin determination of such a flash fire can be supported by accurate witness observations and the analysis of the potential ignition sources in the areas where the vapor or gas could have existed. When the analysis of fire patterns is the only means of determining the origin, the investigator should be aware that the resultant ignition of secondary fuels and compartment flashover could have altered or obliterated the subtle patterns created by the flash fire.

6.5.10.2.2 Fuel Consumption. The difficulty in detecting patterns caused by flash fires is the result of the total consumption of available fuel without significantly raising the temperatures of other combustibles. In this case, the fire patterns may be superficial and difficult to trace to any specific point of ignition as in Figure 6.5.10.2.2. In addition, separate areas of burning from pocket fuel gas may exist and further confuse the tracing of fire spread.

6.5.10.2.3 Saddle Burns. Saddle burns are distinctive U- or saddle-shaped patterns that are sometimes found on the top edges of floor joists. They are caused by fire burning downward through the floor above the affected joist. Saddle burns display deep charring, and the fire patterns are highly localized and gently curved. They also may be created by radiant heat from a burning material in close proximity to the floor, including materials that may melt and burn on the floor (e.g., polyurethane foam). Ventilation caused by floor openings may also contribute to the development of these patterns, shown in Figure 6.5.10.2.3.

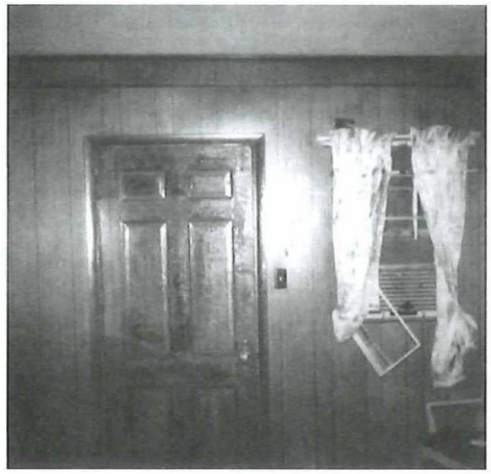


FIGURE 6.5.10.2.2 Blistering of Varnish on Door and Slight Scorching of Draperies, the Only Indications of the Natural Gas Flash Fire.

FIGURE 6.5.10.2.3 Saddle Burn in a Floor Joist.

N **6.6 Fire Effects on Electrical Systems and Components.**

N **6.6.1 Electrical Faults.** An electrical fault will usually produce characteristic damage that may be recognized after a fire. Evidence of these faults may be useful in locating the area of origin. The damage may occur on conductors, contacts, terminals, conduits, or other components. However, many kinds of damage can occur from nonelectrical events. Section 6.6 will give guidelines for deciding whether observed damage was caused by electricity or fire attack. These guidelines are not absolute, and many times the physical evidence will be ambiguous and will not allow a definite conclusion. Conductors may be damaged before or during a fire by other than electrical means and often these effects are distinguishable from electrical activity.

N **6.6.1.1** As fire impinges on electrical wiring, the first change will be the degradation of the insulating materials. This degradation will depend on the duration of and exposure to the fire. If the exposure is sufficient, insulation breakdown can occur, potentially leading to an electrical fault. The insulation may be only damaged, or it can be completely consumed. However, it is

conductors upstream from the point of arc severing may remain energized if the overcurrent protection does not function. Those conductors can sustain further arcing through the char. In a situation with multiple arc severings on the same circuit, arc severing farthest from the power supply occurred first, but only in the cases where the ungrounded (i.e., hot) conductor is severed. If the ungrounded conductor remains intact downstream of the sever location [i.e., the grounded (neutral) or grounding (ground) conductors are severed], arcing can continue to occur. Investigators should attempt to determine what conductors were severed during the arcing event to fully evaluate this scenario. The investigator should find and document as much of the conductors as possible to gather all available data.

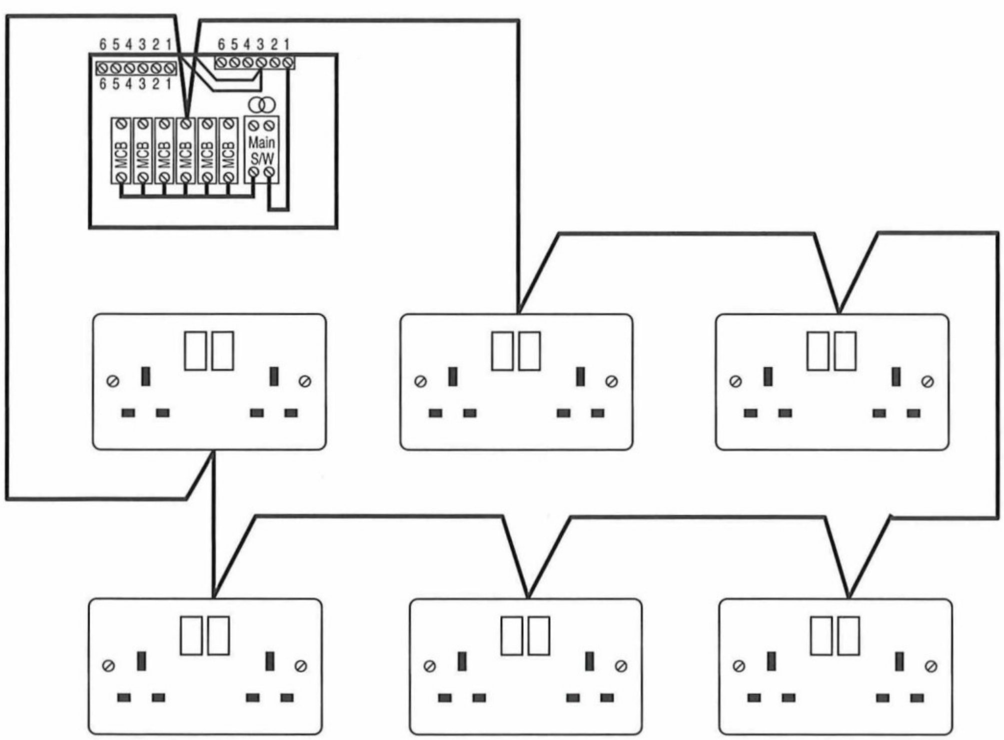
N **6.6.8.2 Inappropriate Assumptions.** Note that the situation described in 6.6.8.1 is not equivalent to concluding that "arcing moves upstream toward the power source." The latter is an erroneous assumption and not supported by science. A direction can only be imputed if there is a sever arc site and an arc site(s) downstream of the sever arc site.

N **6.6.8.3 Sever Arc Site.** If there is a sever arc site and an arc site downstream of it, then the direction of fire involvement along that circuit can be deduced, since the damage had to occur first at the downstream location, then later at the upstream location (due to the fact that no arcing can occur beyond a point where power was cut off). This direction pattern can help in understanding the movement of the fire but cannot by itself establish the point of fire origin. Note that comparisons on timing or directionality cannot be made between arc sites on different circuits.

N **6.6.8.4 Backfeeding.** In some instances, backfeeding or contact with energized conductors may allow for the energization of conductors where the circuit protection devices (e.g., circuit breakers or fuses) have operated to shut down the circuit (tripped) or were in the off position.

N **6.6.8.5 Ring Circuit.** Some locations/countries use a ring approach in building wiring rather than the radial or branch circuit common in North America *(see Figure 6.6.8.5)*. In such electrical systems, it may not be possible to determine whether arc sites are electrically upstream or downstream from each other.

N **6.6.8.6 Absence of Arc Melting.** The absence of arc melting can be important evidence and should be noted so that it is clear that the particular area was examined, but that no arc sites were found. The lack of arc melting may indicate that parts of the electrical system were not energized at the time of fire impingement, which can help establish the progression of the fire and a time line of events. However, it is important to remember that there are some instances in which an arc site may not be created on an energized circuit, such as when arc fault or ground fault circuit interrupting devices are used. It is also possible for fire impingement on a panelboard to cause the circuit breakers to trip thermally from the heat of the fire. This thermal activation can occur prior to the insulation on the branch circuits becoming sufficiently damaged and allowing arcing to occur.



N **FIGURE 6.6.8.5 Ring Circuit Configuration Found in the United Kingdom.**